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CARBON-IN-PULP GOLD ADSORPTION FROM CYANIDE LEACH SLURRY OF LAKE CHARLOTTE FLOTATION CONCENTRATE

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by

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ABSTRACT

Flotation concentrate with gold content in the 120-160 g/t range was obtained from a sample of an old tailing site (Lake Charlotte) in Nova Scotia. The concentrate was cyanide leached with gold extraction of up to 97%, in 48 hours. Cursory carbon-in-pulp studies indicated that loading of coconut shell carbon to more than 6 kg/t of Au would be easily achieved. Gold adsorption rate data were determined and an equilibrium adsorption curve was tentatively developed.

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ADSORPTION, PAR LE PROCEDÉ "CHARBON-EN-PULPE", DE L'OR CONTENU DANS LA PULPE CYANURÉE D'UN CONCENTRÉ DE FLOTTATION PRÉLEVÉ À LAKE CHARLOTTE

par

M.A. Cristovici*, H.Z. Liu**, G.W. Leigh***

RÉSUMÉ

Un concentré de flottation dont la teneur en or variait de 120 à 160 g/t a été obtenu à partir d'un échantillon prélevé sur un ancien site de rejet (Lake Charlotte) en Nouvelle-Ecosse. La lixiviation au cyanure a permis d'extraire jusqu'à 97% de l'or en 48 heures. Une étude préliminaire de l'adsorption de l'or parle procedé charbon-en-pulpe indique qu'il est possible de réaliser facilement l'adsorption d'une charge d'or de plus de 6 kg/t sur du charbon d'écorce de noix de coco. On a déterminé les taux d'adsorption de l'or et on a tenté de tracer la courbe d'équilibre de l'adsorption.

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INTRODUCTION

A process consisting of flotation followed by the cyanidation of the concentrate was developed by CANMET to recover the gold contained in some old tailings ponds located in Nova Scotia (1,2).

The testwork was carried out on samples orginating from two sites: Lake Charlotte assaying approximately 14 g/t Au and Forest Hill containing 2 g/t Au. The overall gold recovery of the process was in the range of 90% for both samples.

The encouraging results obtained with this material generated further interest in investigating the possibility of recovering the gold dissolved in cyanide leach slurry by carbon-in-pulp adsorption technique.

A tailing sample from the Lake Charlotte pond was used to initiate the CIP testwork. Flotation and cyanidation of the concentrate were carried out under the conditions previously established for this material (1).

The leach slurry resulting from the cyanidation of the concentrate was then contacted with coconut shell activated carbon and the gold adsorption was studied. Based on the gold adsorption rate data, an equilibrium curve for the adsorption of gold on activated carbon was developed.

A reduced number of tests were carried out since only a small amount of material was available for these experiments, therefore the results of this investigation should be regarded as informative.

OBJECTIVES OF THE INVESTIGATION

The objectives of the investigation were:

1. To determine the adsorption rates on carbon for gold dissolved in cyanide leach slurry.
2. To develop an equilibrium curve for gold adsorption on coconut shell carbon.

OBTAINING THE FLOTATION CONCENTRATE AND THE CYANIDE LEACH SLURRY UNDER CONDITIONS PREVIOUSLY ESTABLISHED

The cyanide leach slurry required for the carbon-in-pulp gold adsorption tests was obtained by processing the Lake Charlotte tailing under the optimum conditions determined in the 1982 CANMET study.

Processing of the gold tailing sample consisted in grinding the ore, flotation of the gold minerals and cyanidation of the flotation concentrate.

The conditions and results of the work to produce the cyanide leach slurry were:

1. Conditions

Ore charge: 15 kg tailing sample

Grinding:

Slurry density: 65% solids

Grinding time: 15 minutes per 1000 g charge

Size distribution: 70-75% -80 µm

Flotation:

Fifteen 1-kg charge flotation runs were performed under the following identical conditions:

Reagents:	Aero float 208	300 g/t
	Xanthate Na-isobutyl (Aero 317)	150 g/t
	MIBC (methylisobutylcarbinol)	100 g/t
Flotation stages		3
Flotation time (total) minutes		8.5
pH: Natural		6.1

Cyanidation of the flotation concentrate

The flotation concentrate was split in 3 equal parts of approximately 500 g each and were cyanide-leached separately under the following identical conditions:

Slurry density:	33% solids
Protective alkali, by lime at	pH 11.0-11.5
Solution concentration:	1 g/L NaCN
Contact time:	48 hours
Size distribution:	97.2%-80µm

No regrind of the flotation concentrate was performed prior to cyanidation. Since the fine material preferentially reported in the flotation product, the size distribution of the concentrate was much finer than that of the ground ore.

2. Results

Flotation

The flotation concentrates obtained from the fifteen batch runs were combined and the composite was assayed for Au, Ag and S. A composite of all flotation tailings was also prepared and assayed for the same elements.

The metallurgical results of the overall flotation process are given in Table 1.

Table 1. Flotation metallurgical results

Product	% Weight	ASSAY			% DISTRIBUTION		
		Au, g/t	Ag, g/t	S%	Au	Ag	S
Concentrate	9.7	140.9	5.50	0.34	93.8	49.3	70.1
Tailing	90.3	1.0	0.61	0.016	6.2	50.7	29.9
Head (calc)	100.0	14.6	1.08	0.05	100.0	100.0	100.0

Cyanidation

The results obtained in the cyanidation of the three portions of the concentrate are shown in Table 2.

Table 2. Results of the concentrate cyanidation

Concentrate portion	Product	Amount mL or g	Assay, Au mg/L or g/t	% Dist Au	Reag. consump. kg/t	
					NaCN	CaO
A	Cyanide sol'n	1009.0	70.65	95.7	1.28	9.2
	Residue	452.5	7.0	4.3		
	Head (calc)		164.53	100.0		
B	Cyanide sol'n	1035.0	45.03	87.1	1.28	9.2
	Residue	444.2	15.6	12.9		
	Head (calc)		120.52	100.0		
C	Cyanide sol'n	1012.0	60.45	97.3	1.28	9.2
	Residue	456.8	3.7	2.7		
	Head (calc)		137.62	100.0		

The gold content of the portion B residue was unrealistically high because of a test accident. A broken pipette tube inadvertently left in the cyanidation bottle acted as a grinding media and abraded the carbon to some extent. The fine carbon with high Au content could not be separated by screening and reported in the cyanide residue drastically increasing its Au assay result.

The leach slurries resulting from the cyanidation of the three portions of the flotation concentrate were further subjected to carbon-in-pulp adsorption tests.

CARBON-IN-PULP ADSORPTION TESTS

Carbon-in-pulp batch adsorption tests were performed using activated coconut shell carbon to evaluate the adsorption rates for gold dissolved in the cyanide leach slurries.

The carbon was regenerated and placed in cyanidation bottle to be loaded with gold. Based on the test results adsorption rates were evaluated and an approximate equilibrium curve was developed.

CARBON REGENERATION

A sample of coconut shell carbon sized between 3.4 - 1mm (6 - 16 mesh) was re-activated by the following procedure:

- Carbon was wet screened on 0.850 mm screen (20 mesh) using distilled water and the screen undersize was discarded.
- The screen oversize was placed in a refractory dish and distilled water was added to form a pulp of 50% solids. The dish was covered and placed in a preheated furnace at 700°C.
- The carbon was left in the furnace for 2 hours at this temperature.
- After 2 hours the carbon was quenched in a clean pail of demineralized water.
- Finally the carbon was filtered and kept moist for the gold adsorption tests.

LOADING THE CARBON

Three carbon-in-pulp adsorption tests were carried out to examine the loading of the activated carbon by gold, at various solution to carbon ratios.

The carbon was added in the cyanidation bottles on the rolls at completion of the leaching and the gold adsorption was monitored for a duration of 24 hours. At the end of the tests the loaded carbon was separated from the pulp by screening on a 0.25 mm sieve.

The conditions of the tests are given in Table 3.

Table 3. Conditions for carbon-in-pulp tests

Test No	Slurry g	Solution g	Solids g	Slurry % Solids	Carbon g	Wt Ratio Sol'n/carbon
1-A	1461.5	1009.0	452.5	31.0	11.2	90.0
1-B	1479.2	1035.0	444.2	30.0	16.4	63.1
1-C	1468.8	1012.0	456.8	31.1	51.3	20.0

The results of gold adsorption on activated carbon are presented in Table 4.

Table 4. Results of gold adsorption on carbon

Results	Test 1-A		Test 1-B		Test 1-C	
	Assay, Au g/t, mg/L mg/g	% Dist Au	Assay, Au g/t, mg/L mg/g	% Dist Au	Assay, Au g/t, mg/L mg/g	% Dist Au
Head, (Flotation conc)	164.53	100.0	120.52	100.0	137.62	100.0
Loaded carbon	6.28	94.5	2.83	86.7	1.19	97.1
Residual solution	0.228	1.2	0.062	0.4	0.035	0.2
Residue	7.0	4.3	15.6	12.9	3.7	2.7
Au, transferred to solution		95.7		87.1		97.3
Au, adsorbed on carbon from solution		98.7		99.5		99.8

Adsorption of gold from the solution to activated carbon was in the 99% range. A maximum carbon loading of 6.28 kg/t Au was achieved.

ADSORPTION-RATE DATA

Samples of slurry periodically removed from the bottles during the C.I.P. process were filtered and the solutions assayed for gold to evaluate the adsorption rates.

The adsorption rate data of the three tests are given in Table 5.

Table 5. Adsorption rates on activated carbon

Time h	Test 1-A			Test 1-B			Test 1-C		
	Solution Au, g/t	Carbon Au, g/t	% Extrac* Au	Solution Au, g/t	Carbon Au, g/t	% Extrac* Au	Solution Au, g/t	Carbon Au, g/t	% Extrac* Au
1	5.36	5882	92.4	1.56	2743	96.5	0.69	1179	98.9
2	2.36	6157	96.7	0.89	2787	98.1	0.45	1184	99.3
4	1.27	6254	98.3	0.70	2800	98.5	0.20	1189	99.7
8	0.84	6292	98.9	0.56	2808	98.8	0.14	1190	99.8
12	0.79	6298	99.0	0.86	2792	98.2	0.20	1189	99.7
24	0.228	6280	98.7	0.0616	2838	99.9	0.035	1192	99.9

*Gold adsorbed on carbon from gold dissolved in solution.

The graphs showing the change in the gold concentration of the solution as function of time are presented in Fig. 1.

The adsorption rate data and the graphs indicated that over 98% gold adsorption occurred after 4 hours for test 1-A, after 2 hours for test 1-B and in less than 1 hour for test 1-C.

EQUILIBRIUM ADSORPTION CURVE

An equilibrium curve for gold adsorption on activated carbon was evaluated based on the gold concentrations of solutions and carbon.

The end-point data selected from Table 5 are given in Table 6.

Table 6. End-point data of tests 1-A - 1-C

Test	Time hours	Solution Au, g/t	Carbon Au, g/t
1-A	24	0.228	6280
1-B	24	0.062	2838
1-C	24	0.035	1192

The end-point data were correlated by the least-squares method and the resulting straight line was drawn in a log-log graph as shown in Fig. 2.

The equation of the line, expressed in units of g/t is as follows:

$$c = 23{,}291\ (S)^{0.8393}$$

where:

c = Au, g/t in carbon

S = Au, g/t in solution

This equation was used to calculate points on the adsorption curve, which were plotted as shown in Fig. 3.

The estimated gold-adsorption equilibrium curve for activated carbon serves as a boundary line beneath which the carbon-in-pulp system must operate.

CONCLUSIONS

The following conclusions can be drawn based on the results of the carbon-in-pulp adsorption tests carried out with cyanide leach slurry of the Lake Charlotte flotation concentrate:

1. Cursory laboratory C.I.P. tests indicated that 3.4-1.0 mm coconut shell activated carbon was loaded to a maximum of 6.3 kg/t Au from a pregnant cyanide solution containing 45-70 g/t Au, leaving a barren solution of a minimum of 0.035 g/t Au.

2. Adsorption rate data showed that over 98% of the gold dissolved in the solution was adsorbed on the activated carbon in less than 4 hours.

3. An approximate equilibrium curve for gold adsorption was developed.

More testwork is required to study in detail the gold adsorption rates at various solution:carbon ratios. Then a more accurate gold-adsorption equilibrium curve can be developed which will provide guidance for the number of stages to be used in the C.I.P. process.

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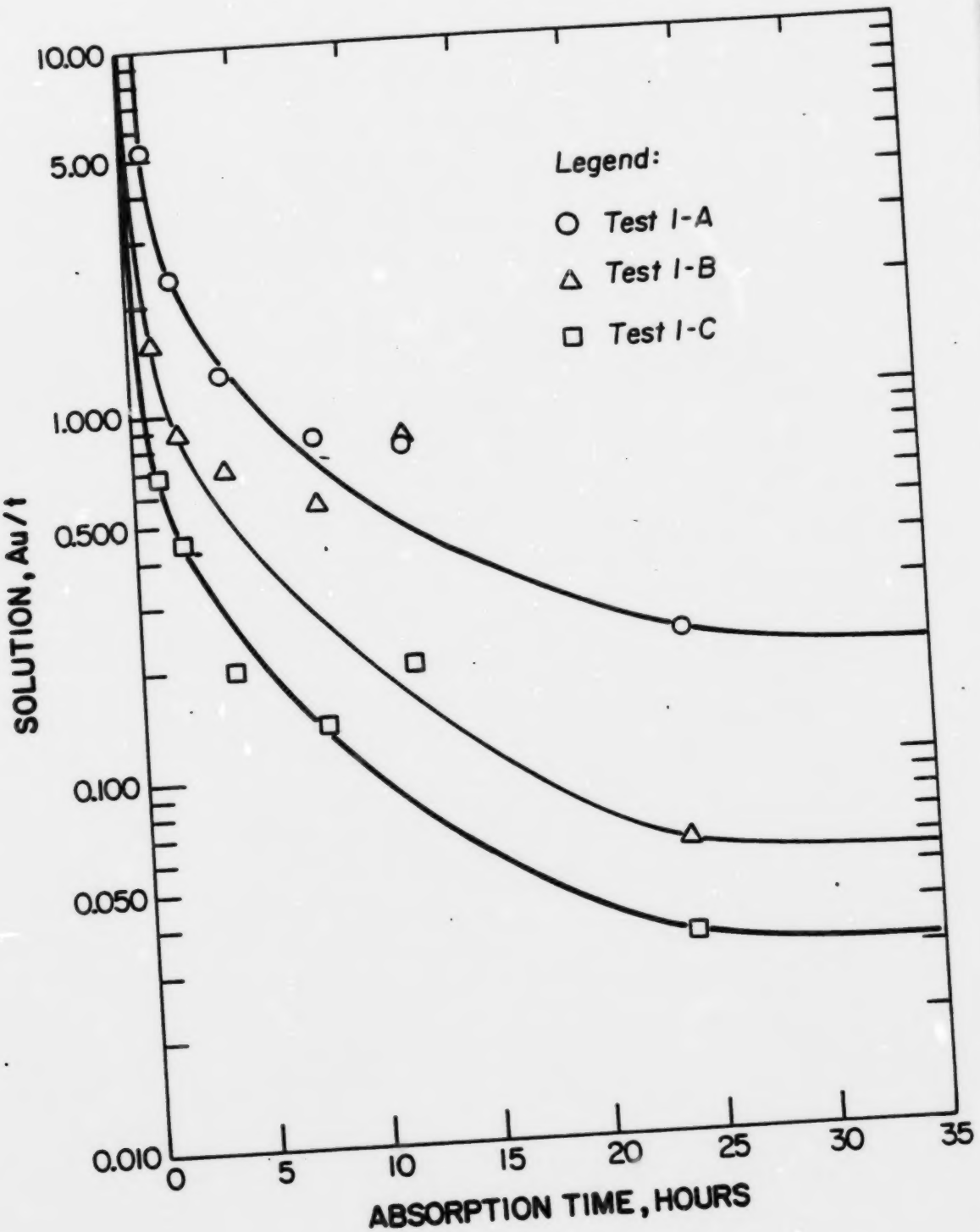

Figure 1 - Time versus solution concentration for gold adsorption on activated carbon.

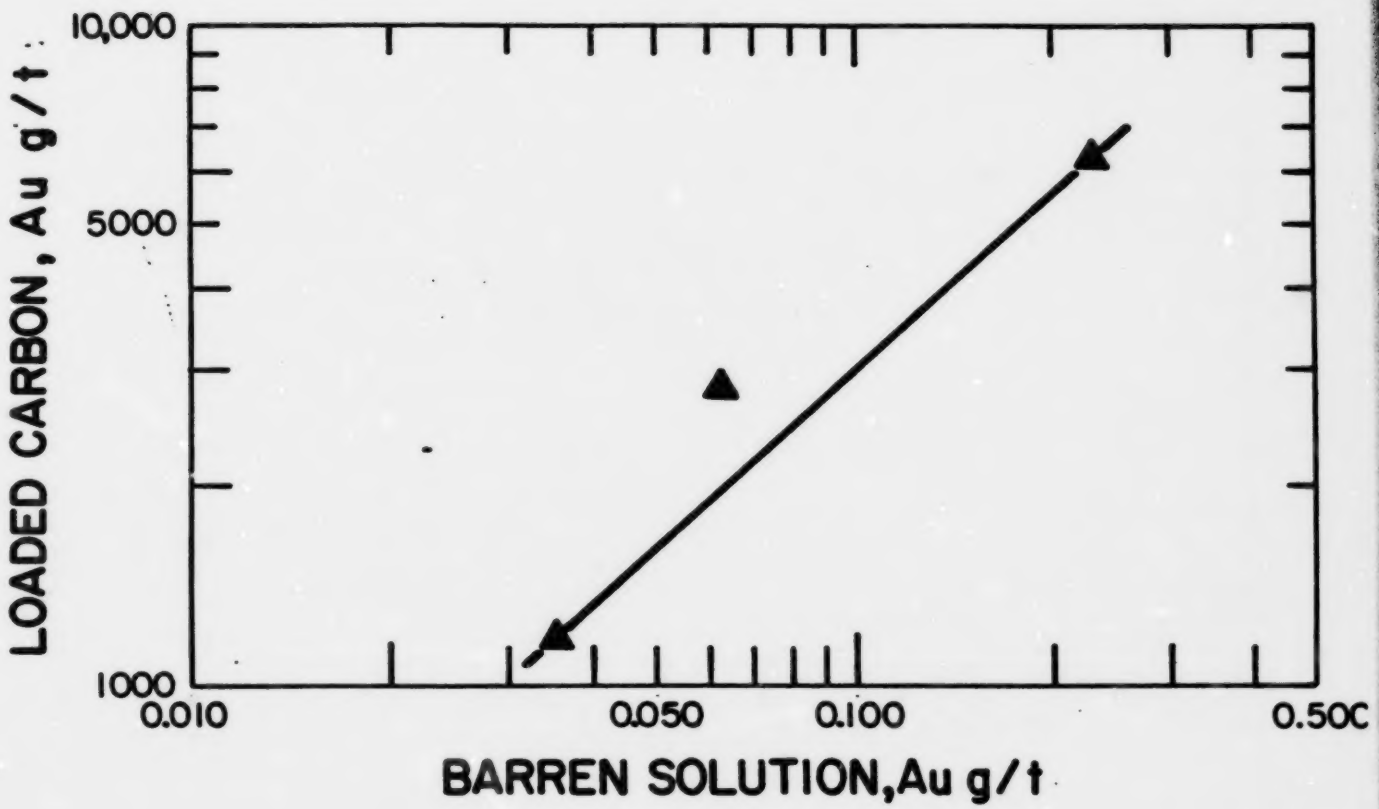

Figure 2 - Log-log plot of an equilibrium curve for gold adsorption on activated carbon.

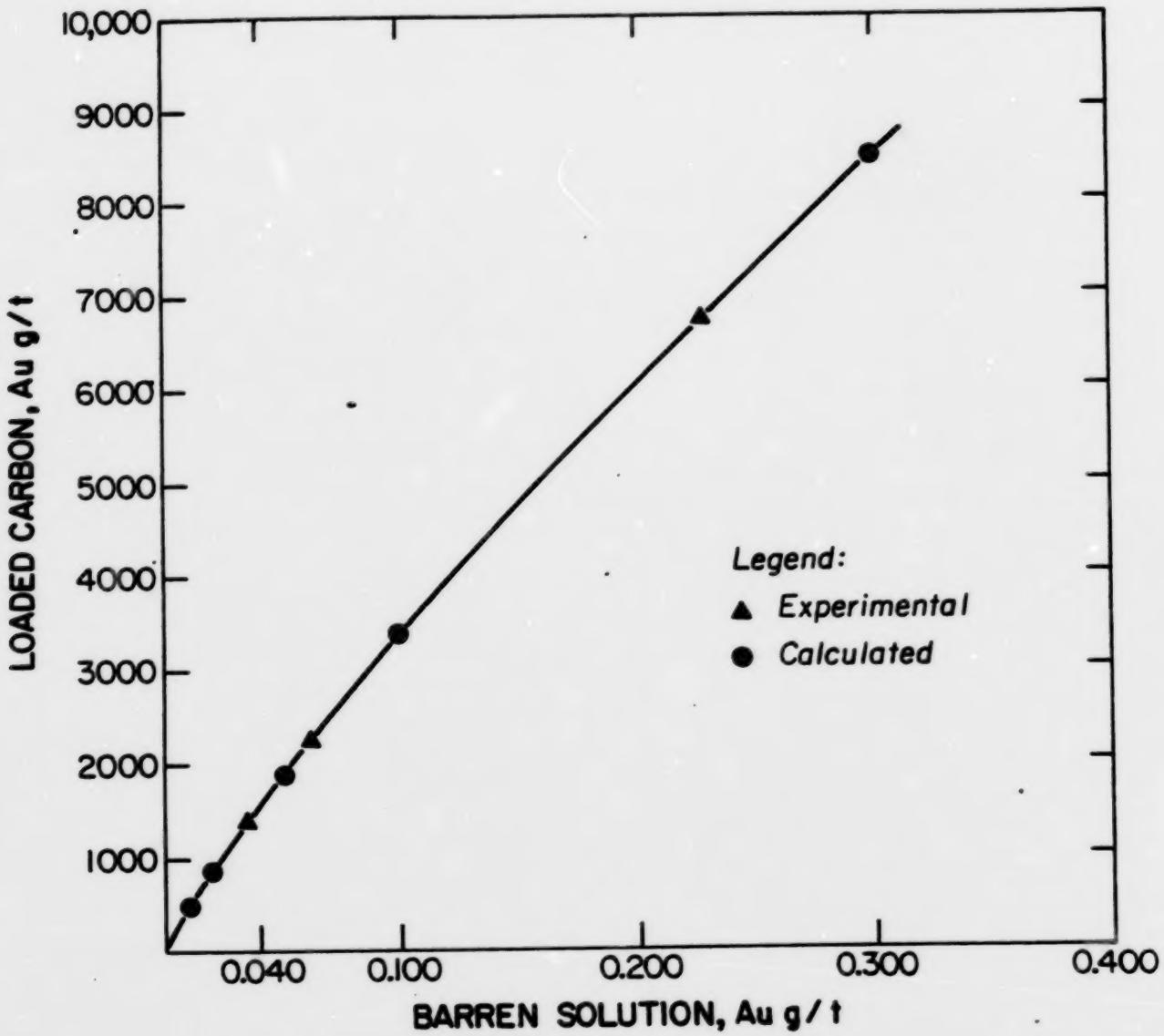

Figure 3 - Equilibrium curve for gold adsorption on activated carbon.

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